

# **Domestic Safeguards:**

## **The Essential Foundation for International Safeguards**

**LANL Safeguards Systems Course – 2009**

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# Outline

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- What are domestic safeguards?
  - Concepts and terminology
- How do domestic safeguards influence international safeguards?
- Overview of domestic safeguards measures
- Concluding remarks

# Definition of Domestic Safeguards

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- **Safeguards.** An integrated system of physical protection, material accounting, and material control measures designed to deter, prevent, detect, and respond to unauthorized possession, use or sabotage of nuclear materials. (*Safeguards and Security Glossary of Terms, U.S. Department of Energy, Office of Safeguards and Security, December 18, 1995*)
- **Note:**
  - Measures include physical protection, material accounting and material control
  - Purposes include deterrence, prevention, detection and response
  - Integration is key. Physical Protection (PP), Material Control (MC), and Material Accounting (MA) must work together.

# International Safeguards are Different

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- The objective of safeguards is the timely detection of diversion of *significant quantities of nuclear material* from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and the deterrence of such diversion by the risk of early detection. (Paragraph 28, *INFCIRC/153, The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*)
- Material accountancy [is] a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures (*Paragraph 29, INFCIRC/153*)
- **Note:**
  - Purposes include detection and deterrence (but only by risk of detection), not prevention or response
  - Measures include material accountancy, containment and surveillance and other complementary measures, but not physical protection

# Security is an Even Broader Concept

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- **Security.** An integrated system of activities, systems, programs, facilities, and policies for the protection of classified information and/or classified matter, sensitive information, nuclear materials, nuclear weapons and nuclear weapon components, and/or the Department's and the Department's contractors facilities, property and equipment. (*Safeguards and Security Glossary of Terms, U.S. Department of Energy, Office of Safeguards and Security, December 18, 1995*)
- **Note:**
  - Covers wide range of valued assets--weapons, materials, information, facilities, property, equipment ...
  - Includes more than just physical protection
  - Again, integration is emphasized
  - Security provides essential underpinnings for safeguards

# Caution about Terminology and Definitions

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- Terms such as safeguards are used differently in different countries and specialist communities.
- Internationally, the word “safeguards” usually means IAEA safeguards, not domestic safeguards
- Even in the US, many people interpret the word “safeguards” to exclude physical protection (notwithstanding the “official” definition)
- Some people refer to physical protection as “security” so that “material accounting, material control and physical protection” are understood as synonymous with “safeguards and security”
- ***Recommendation: When misunderstandings are possible, be specific about what you mean—material accounting, material control, physical protection, and so forth***

## IAEA Safeguards are Built upon Domestic Safeguards

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- **State System of Accounting and Control (SSAC).**  
“The State shall establish and maintain a system of accounting for and control of all *nuclear material subject* to safeguards .... [S]uch safeguards shall be applied in such a manner as to enable the Agency to verify ... findings of the State's system. The Agency's verification shall include, inter alia, independent measurements and observations.... The Agency, in its verification, shall take due account of the technical effectiveness of the State's system. (*Paragraph 7, INFCIRC/153*)

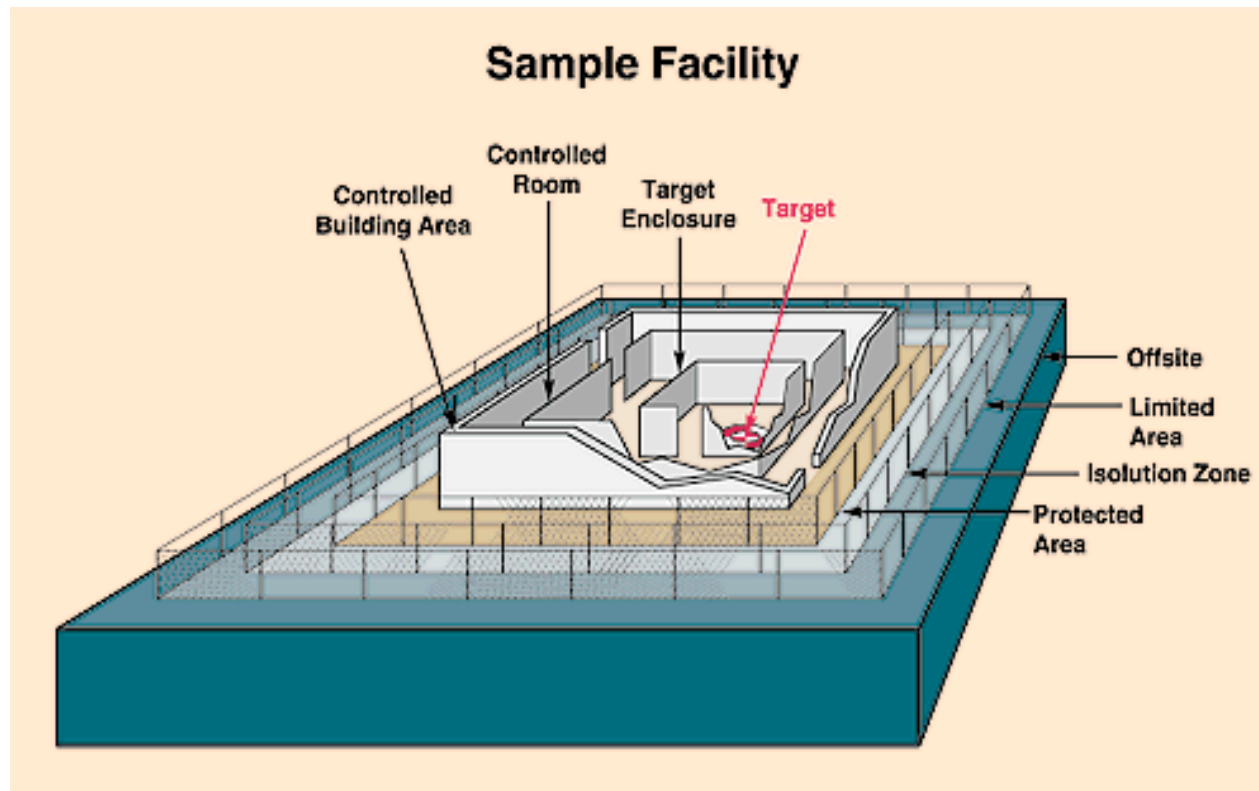
## Two Key Overarching Principles

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- **Graded Safeguards.** The concept of providing the greatest relative amount of control and effort to the types and quantities of SNM [special nuclear material] that can be most effectively used in a nuclear devices. (*Manual for Control and Accountability of Nuclear Materials*)
- **Defense-in-Depth.** The use of multiple, independent protection elements combined in a layered manner so that system capabilities do not depend on a single component to maintain effective protection against defined threats. (*Safeguards and Security Glossary of Terms*)



# Defense-in-Depth (Layered Protection)



Layers may encompass different technologies and measures, as well as spatial layers

# Graded Safeguards Considerations

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- Attractiveness – ease to produce a weapon
- Category – amount of material coupled with attractiveness

# Graded Safeguards Attractiveness— the Department of Energy Approach

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- Level A – Weapons
- Level B – Pure Products
- Level C – High-Grade Materials
- Level D – Low-Grade Materials
- Level E – All Other Materials

**Note:** Other countries and agencies use different approaches.

# Graded Safeguards Table

Attractiveness Level	Pu/U-233 Category (Kilograms)			
	I	II	III	IV
<b>A</b>	All Quantities	N/A	N/A	N/A
<b>B</b>	$\geq 2$	$< 2$ , but $\geq 0.4$	$< 0.4$ , but $\geq 0.2$	$< 0.2$
<b>C</b>	$\geq 6$	$< 6$ , but $\geq 2$	$< 2$ , but $\geq 0.4$	$< 0.4$
<b>D</b>	N/A	$\geq 16$	$< 16$ , but $\geq 3$	$< 3$
<b>E</b>	N/A	N/A	N/A	Reportable

# Protection -- Control -- Accounting

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- **Protect**: Keep the adversary away from the material
  - Emphasizes use of measures such as guards, vaults, locks, exclusion areas
- **Control**: Govern the movement, location and use of material (and the interactions between people and materials)
  - Emphasizes use of procedures, complemented by technology, and integrated with physical features such as doors, gates, zones, to detect and assess unauthorized activities
- **Account**: Use information about inventories and flows of materials to detect discrepancies between “what should be” and “what is”
  - Emphasizes separation of functions and independence of different sources of information
  - Tests whether other measures have actually been effective, by positively confirming the status of the material
- **Caution**: These measures can overlap, which is one reason why integration is important

## DOE Order 474.1A—Control and Accountability of Nuclear Materials

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- Each facility must control and account for nuclear materials according to the strategic and monetary importance of the nuclear materials and the consequence of their loss. MC&A programs must deter and detect theft and diversion of nuclear material by both outside and inside adversaries

# Nuclear Material Accountability

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- Nuclear Material Accountability – the part of the Materials Control and Accountability program encompassing systems and procedures to:
  - Perform nuclear material measurements
  - Verify the location and quantities of nuclear material
  - Maintain records and reports
  - Perform data analysis to account for and detect loss of nuclear material
  - Investigate and resolve apparent loss of nuclear material

# Nuclear Material Accounting

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- Principles and practices of systematically recording, reporting, and interpreting nuclear material transactions and physical inventory data



# Accountability vs. Accounting

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- Accountability – responsibility or answerability
- Accounting – systematically recording and reporting transactions

# Nuclear Material Accounting (IAEA Definition)

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- Activities carried out to establish the quantities of nuclear material present within defined areas and the changes in those quantities within defined periods.
- Elements of nuclear material accounting include:
  - establishment of accounting areas,
  - record keeping,
  - nuclear material measurement,
  - preparation and submission of accounting reports, and
  - verification of the correctness of the nuclear material accounting information.

# Elements of Material Accountability

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- Accounting systems (accounting database and procedures, account structure, records and reports)
- Physical inventories
- Nuclear material transfers (external, internal)
- Measurements and measurement control
- Material control (detection) indicators (shipper-receiver differences, inventory difference evaluation, evaluation of other inventory adjustments)

# Material Balances—the Bottom Line for Materials Accounting

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- Material balances are calculated to test the safeguards system. They can be an indicator of loss, diversion, or other problems.
- The “book inventory,” i.e., the amount of material you are supposed to have on hand, should equal the “physical inventory,” i.e., the amount you actually have.
- Analogous to balancing a checkbook
  - The amount of money actually in your account at the end of the month should match the amount you had at the beginning of the month, plus any deposits, minus any withdrawals

## Material Balances—the Bottom Line for Materials Accounting (cont'd)

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- Ideally, Beginning Inventory + Additions – Removals should equal Ending Inventory
  - Conservation of mass
- By actually measuring all these terms, we can test how closely the ideal is approached
- Inventory Difference =  
Beginning inventory (measured previously)  
+ measured additions  
– measured removals  
– measured ending inventory

## Material Balance Example

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Inventory Difference =

+1000 g (beginning inventory)

+ 0 g (additions)

-117 g (removals)

-900 g (ending inventory)

= -17 g

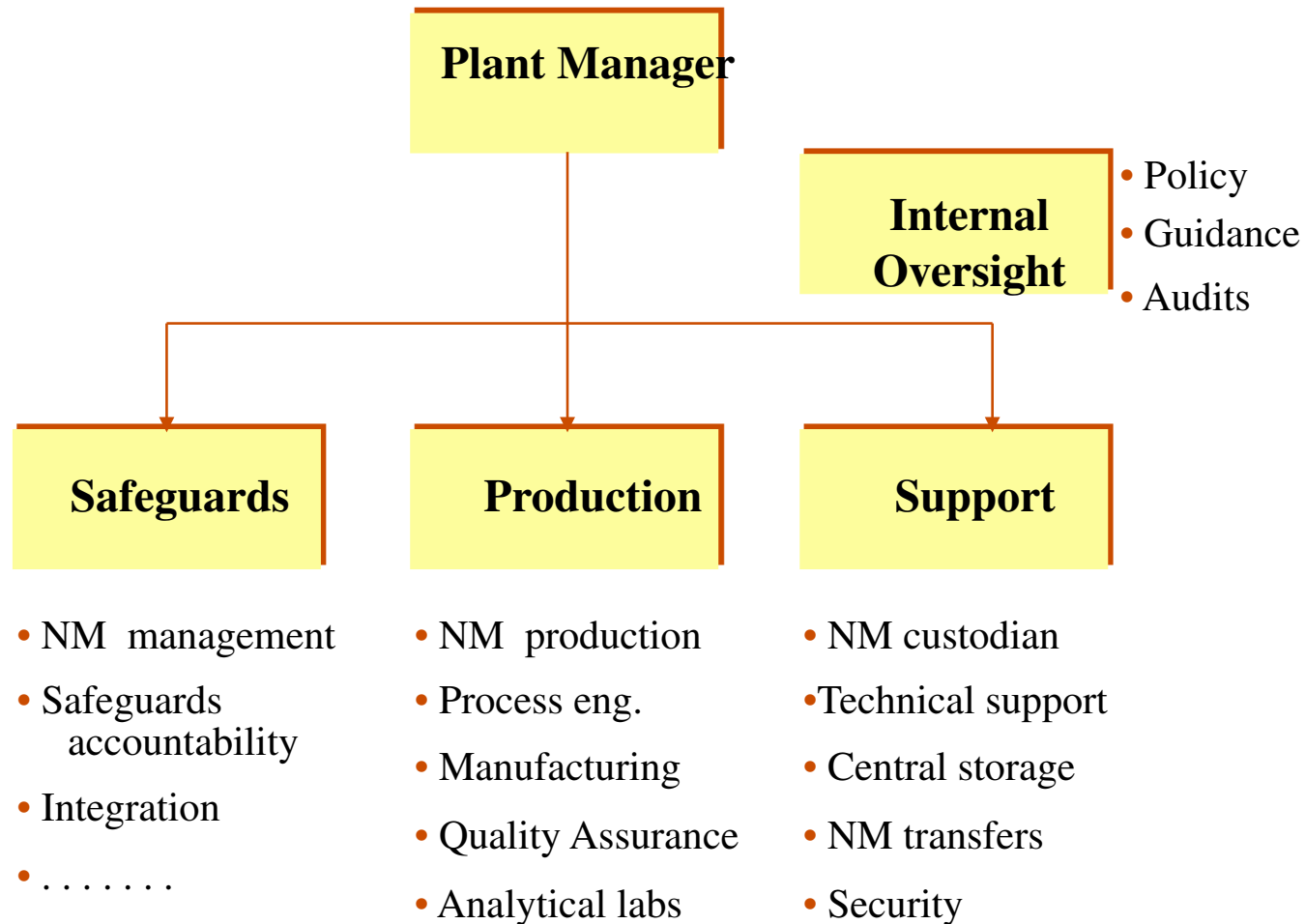
We “gained” 17 g. This is a small fraction of the beginning inventory (1.7%). What could cause such a difference?

## IAEA Uses a Different Term for Inventory Difference--Material Unaccounted For (MUF)

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- $MUF = (PB + X - Y) - PE$ 
  - PB is the beginning physical inventory
  - X is the sum of increases to inventory
  - Y is the sum of decreases from inventory
  - PE is the ending physical inventory
- MUF should = zero in a perfect world
  - Item facilities – Non-zero MUF **not** expected
  - Bulk-handling facilities – Non-zero MUF **IS** expected

# Example Organizational Structure





# The Accountability System

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- Demonstrates that materials are present
- Provides timely detection of material loss
- Defines the location of the loss
- Allows a material balance to be drawn that quantifies the loss

# Nuclear Materials Control

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- The part of the safeguards program encompassing management and process controls to:
  - Assign and exercise responsibility for nuclear material;
  - Maintain vigilance over the material;
  - Govern its movement, location, and use;
  - Monitor the inventory and process status;
  - Detect unauthorized activities for all nuclear material; and
  - Help investigate and resolve apparent losses of nuclear material.

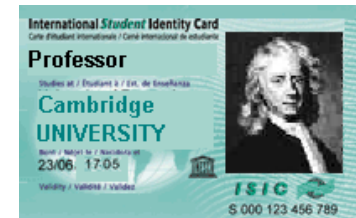
# Elements of Material Control

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- Access controls (materials access, data access, equipment access, and other considerations such as controls during emergencies)
- Material surveillance (monitoring devices, sensors, two-person rule, monitoring by external personnel)
- Material containment (material access areas, protected areas, material balance areas, storage areas, processing areas)
- Detection/Assessment (tamper-indicating devices, portal monitoring, waste monitors, daily administrative checks, other detection assessment mechanisms)

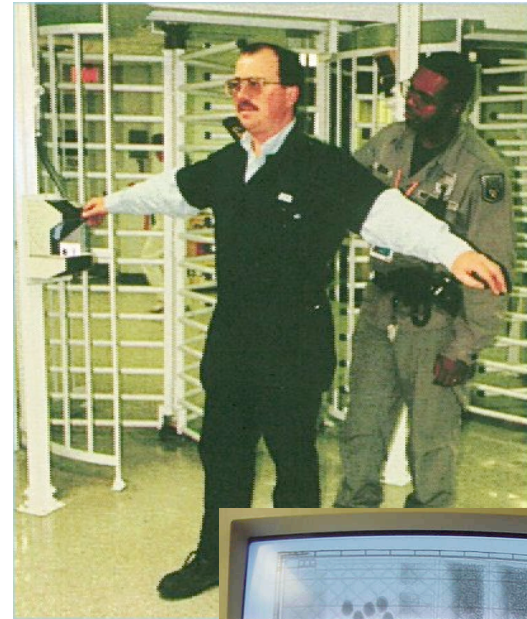
# Entry/Exit Control

- Authorization using:
  - Picture badge inspection
  - Electronic credential
  - Personal identification number (PIN)
  - Badge exchange
  - Biometrics



## Entry/Exit Control *(cont'd)*

- Contraband detection
  - Metal detector
  - Explosives detector
  - X-ray for packages
  - Nuclear material detector
    - Medical isotopes
  - Package inspection by personnel
  - Personnel search
    - Routine and random
- Emergency exit controls and procedures



## Entry/Exit Control *(cont'd)*

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- Personnel restriction after emergency exit
- Emergency exit controls and procedures





# Portal Monitoring

- Monitoring of material being moved through boundary (PA, MAA, and MBA)
- All Personnel and vehicle entering or leaving the MAA or PA are subject to monitoring
- Metal detectors used to detect shielding
- Detect insiders trying to remove SNM

Effectiveness of this safeguards element is critically tied to MC&A Material Transfer Procedures, Measurement, and Material Control Procedures.



# Metal Detectors

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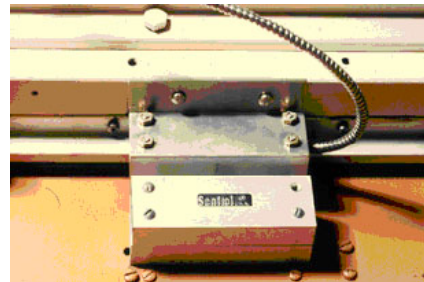
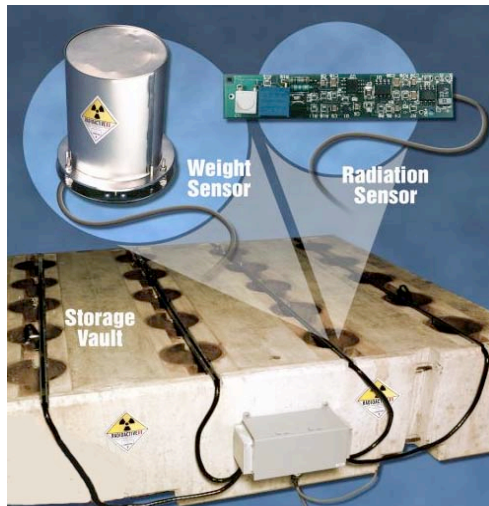
- Entry
  - Adjusted to detect weapons
- Exit
  - Adjusted to detect shielding material
- General
  - Operational testing
  - Sensitivity testing and calibration
  - Personnel training





# Surveillance Systems

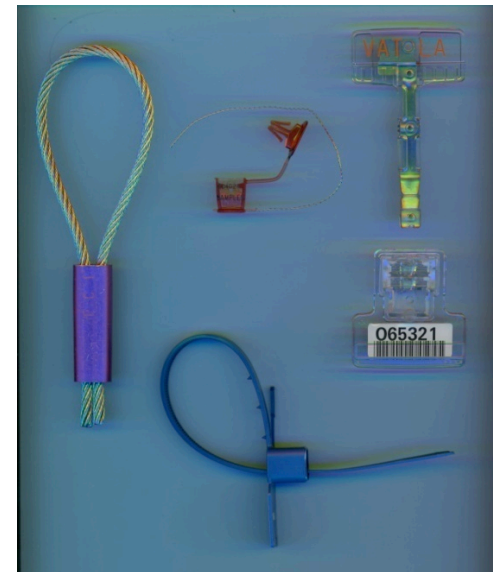
- Video
- Intrusion systems (volumetric, infrared, vibration)
- Door alarms
- Microwave....



# Tamper-Indicating Devices

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- Detect attempts to access material or locations
- Not intended to physically prevent access
- Used in combination with other systems
- TIDs applied:
  - After measurements
  - After inventories
  - During transportation



# Tie-Downs

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Material tie-downs can be used to add delay.

They can be used to control access and hence complicate unauthorized removal of nuclear materials.



# Shipping Monitors

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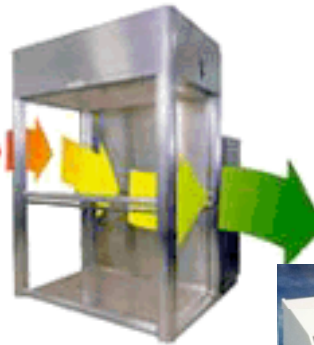
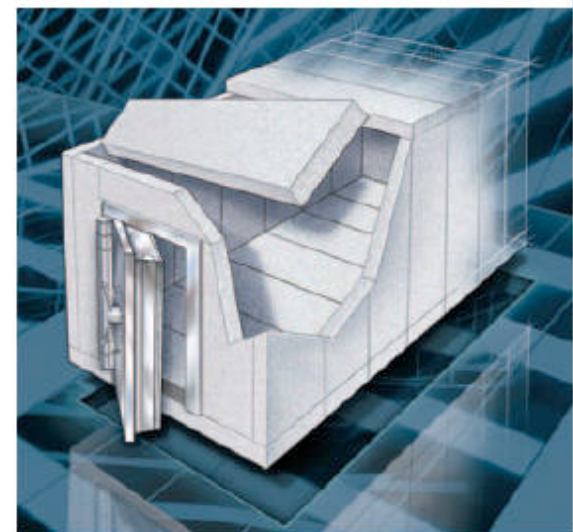
- Shipping portals
- Vehicle Truck Portals
- Waste (clean and contaminated)





# Barriers and Delay Systems

- Fences
- Walls and doors
- Locking mechanisms (e.g., combinations, multiple, electronic)



# Waste Monitoring

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- Detect theft or diversion through waste streams
- Identify all waste streams that cross boundaries (PA, MAA, MBA)
- Physical inventories and evaluation of inventory adjustments are part of a overall program
- Installing, maintaining, and monitoring waste monitoring equipment

## Concluding Remarks

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- Domestic safeguards provide the foundation for international safeguards
- If the foundation is absent, international safeguards cannot work
- If the foundation is present and well-functioning, international safeguards will be much more effective in detecting problems, if there are any, and in assuring that states are fulfilling their obligations, if that's the case.